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Hazardous Materials Problems in Earthquakes



EXECUTIVE SUMMARY

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Hazardous material releases occur in earthquakes. As our metropolitan areas grow, more people live and work near industrial and commercial facilties with hazardous materials. At the same time, both the San Francisco Bay Area and the Los Angeles basin will continue to experience frequent moderate, and, occasionally, major, earthquakes. The 1980s marked the beginning of a period of greater seismicity in the San Francisco Bay Area than experienced since 1911.

Hazardous materials problems can occur with smaller earthquakes of magnitude 5 to 6. However, the number of these problems, and the size of the area affected, increases dramatically for larger earthquakes and for earthquakes in urban areas. The recent Loma Prieta earthquake caused spills from southern Monterey to Napa counties.

This executive summary highlights the findings and conclusions of a two-year research project aimed at answering the following questions:

- What types of problems cause hazardous materials releases in earthquakes?
- What other factors can complicate our ability to respond to these releases?
- What specific measures or strategies can be used by private businesses to mitigate these problems?
- What options are available for local governments to increase the safety of their own facilities, as well as to encourage more action by private businesses in their community?
- Where can one go to get additional information?

ASSOCIATION OF BAY AREA GOVERNMENTS
NOVEMBER 1990

Purpose

The principal objective of this ABAG project is to help those responsible for business and government programs relating to hazardous materials or earthquakes do a better job of mitigating some of these joint problems. We can learn from the past and we can learn from each other.

The project was initiated before the Loma Prieta earthquake in October 1989. That earthquake confirmed earlier conclusions, yet provided additional information on what types of mitigation measures tend to work, and what types tend to be nothing but "false friends."

The two-year research effort was funded by the National Science Foundation's Earthquake Hazard Reduction Program.

Hazardous Materials

A good working definition of a hazardous material is provided by the California Office of Emergency Services (1982) in the ***State Hazardous Materials Contingency Plan***:

> A hazardous material is a substance or combination of substances which, because of quantity, concentration, physical, chemical or infectious characteristics may either:
> a. cause, or significantly contribute to an increase in deaths or serious illness; or
> b. pose a substantial present or potential hazard to humans or the environment.

Earthquakes

Earthquakes have a number of different effects.

- Surface fault rupture may occur and is caused by the ground on one side of the fault moving relative to the ground on the opposite side.
- Although the ground always shakes, the severity of shaking depends on the ***magnitude*** of the event, the ***distance from the fault***, and the type of ***geologic material*** underlying the area.
- Some ground fails, resulting in landsliding, liquefaction, or excessive settlement.

The degree of damage depends not only on the severity of the earthquake's ***geologic*** effects, but also on the susceptibility of individual facilities and their contents to damage. Almost all hazardous materials incidents result from the effect of ground ***shaking*** on facilities and equipment. The shaking damage to contents also increases higher up in buildings, particularly in flexible steel-frame buildings.

Types of Problems

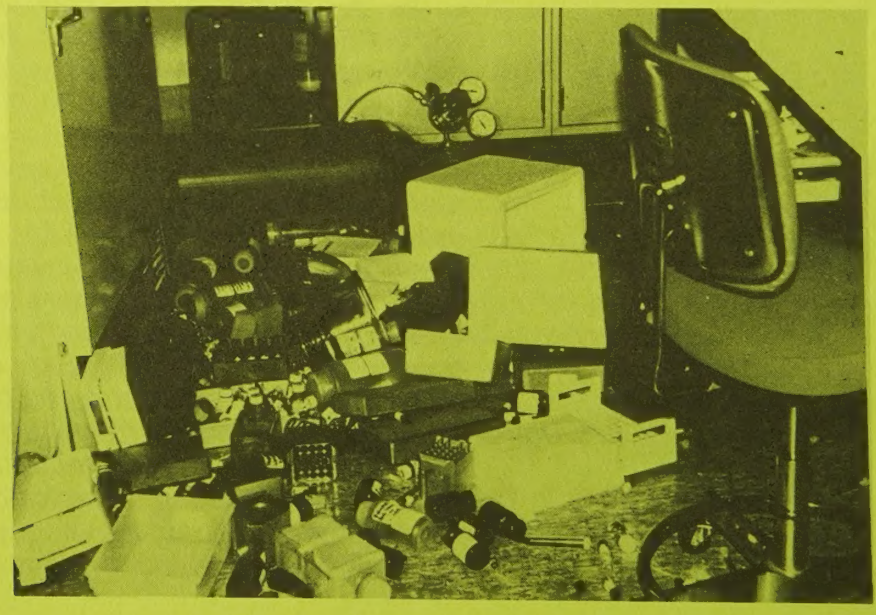
The types of failures which cause hazardous materials releases during earthquakes include:

(a) building structural failures;
(b) dislodging of asbestos or encapsulated asbestos;
(c) underground pipeline breaks due to soil movement;
(d) above-ground pipeline breaks due to (1) breaks in short connector pipes due to differential movement between pipes and structures, (2) impact from other structures or equipment, or (3) damage from failing pipe supports;
(e) cylindrical storage tank failures due to "elephant's foot" buckling, weakening from corrosion, or sloshing of contents;
(f) toppling of elevated tanks;
(g) shifting and overturning of horizontal tanks;
(h) sloshing from open-topped tanks;
(i) falling containers and shelves, particularly in (1) hospital, school or business laboratories or (2) liquor, drug or grocery stores; and
(j) industrial equipment problems due to sliding or overturning, or internal failures; and

Emergency Response Complications

Other factors can complicate the ability to respond to these releases, including:

(a) breakdowns in utilities, including communications, water, and power;
(b) people not following established procedures or not using restraining devices;
(c) malfunctions of control or alarm systems;
(d) shortages of emergency and clean-up personnel;
(e) disruptions of transportation supply/distribution systems; and
(f) indirect impacts due to damage to raw material suppliers or equipment suppliers.



PRIVATE BUSINESS ACTIONS

Assess Risk

Businesses should improve their knowledge by conducting:
(a) general hazardous material inventories and audits; and
(b) earthquake vulnerability analyses.
Initial risk assessments can point out ways to avoid risk through:
(a) general hazardous material inventory control;
(b) asbestos abatement;
(c) avoiding areas of problem geologic/soils conditions; and
(d) use of "buffer" zones.

Mitigate

The potential for hazardous materials releases can be reduced through relatively inexpensive, but not trivial, strategies, including:
(a) use of special structural designs for buildings, tanks, and pipeline supports;
(b) use of specially-designed shelving systems or containers;
(c) use of seismic restraints on equipment or computer floors (such as bracing, anchors, and straps); and
(d) control of risk through secondary containment or chemical isolation and separation of incompatible chemicals.

Avoid Inadequate "Solutions"

Several mitigation measures are inadequate and should be avoided.
(a) Tanks and pipelines can have problems due to inadequate attention to ***details***.
(b) Anchoring thin-walled tanks may make leakage ***more*** likely by contributing to the puncturing of the vessel.
(c) C-clamp restraints for gas cylinders can slip off lab benches.
(d) Gas cylinders can slip out from under single chains. Although this risk is low for those not in use, cylinders in use should have two chains (one high, one low).
(e) Cupboard doors (including sliding doors) can open in earthquakes. They should be fitted with positive latches.
(f) 1" to 1-1/2" shelf lips may not be adequate to restrain reagent bottles in ***violent*** ground shaking. Lip designers should look at the size and shape of what is on the shelf.
(g) Shelf anchors can fail if designed to restrain empty, rather than fully loaded, shelves.
(h) Sloshing can occur out of shallow secondary containment areas. Such containment needs to be ample.
(i) Nothing is ***too heavy*** to worry about!

Improve Emergency Response

Adequate emergency capabilities are particularly important.
(a) Use back-up systems for power, communications and water.
(b) Improve evacuation routes through (1) avoiding placing shelving in major exit corridors, (2) reducing the risk of window breakage, and (3) structural retrofit of exit areas.
(c) Improve the usefulness of emergency personnel through (1) training of special response and inspection teams, (2) anchoring furniture and equipment in their offices; and (3) using databases to track those personnel and their training.
(d) Develop emergency response and warning systems.

Train

Employee training programs are essential. If not trained, employees can be very "innovative" in defeating mitigation -- and in designing inadequate "solutions."

LOCAL GOVERNMENT ACTIONS

Local governments have different roles related to hazardous materials problems in earthquakes. First, they own and operate facilities that use and store hazardous materials. Next, they can encourage private businesses to take a more active role in mitigating potential releases in an earthquake. Finally, they respond to hazardous materials emergencies during earthquakes.

Their Own Facilities

The specific types of strategies available to local governments for their own facilities are similar to those available to private businesses. Thus, local governments should review the strategies listed on the previous page for businesses. They should also take a hard look at the facilities which are essential to their emergency response, including their Emergency Operations Center, police department and fire stations. A small natural gas line leak has forced the evacuation of an EOC. A sprinkler line break could disrupt emergency communications.

Risk Assessment

Local governments should encourage businesses to be active in anticipating and mitigating these types of problems. Such advice should not be limited to the larger companies; our research has indicated that the smaller companies, including general retail stores, gas stations, and pharmacies, also can have problems yet lack in-house expertise to clean up a spill.

Roles

Essential to such a program is knowledge of both aspects of the problem. First, a local government should have an accurate inventory of the location of hazardous materials within the businesses in their community. Second, it should conduct an earthquake vulnerability analysis to identify:

(a) the general extent of ground shaking expected on the different geologic materials found in its jurisdiction;
(b) structures containing hazardous materials that are a collapse hazard, or structures where one can expect greater-than-average damage to contents;
(c) the adequacy of nonstructural precautions currently used by businesses in their community; and
(d) the adequacy and training of in-house emergency response capabilities of the businesses.

Compare your hazmat and earthquake databases!

Standards and Requirements

Fire and hazmat inspectors should use standard checklists for identifying common nonstructural deficiencies, such as inadequate cylinder restraints and shelf lips, when conducting periodic inspections of facilities. Local designated agencies reviewing California's Risk Management and Prevention Programs (RMPPs) should ensure that the reports include an assessment of seismic considerations. They also may adopt standards that are more stringent than those mandated by the state or federal governments for facilities handling hazardous materials. For example, storage or handling of hazardous materials (above a threshold quantity) could be prohibited in seismically suspicious buildings (such as unreinforced masonry buildings), or in areas subject to the strongest shaking (such as Bay mud in the San Francisco Bay Area).

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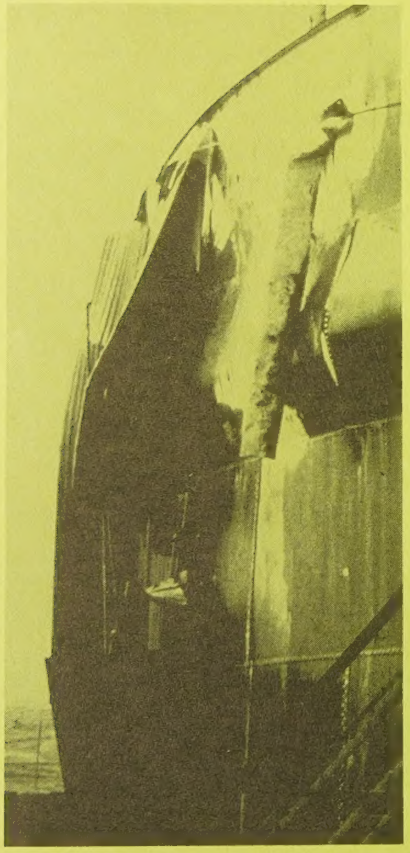
CONCLUSIONS

1. Learn from the past.
2. ***Design*** changes in the context of the entire system.
3. Use appropriate engineering and design professionals with earthquake-related design experience.
4. Periodically inspect both existing programs and equipment.
5. Require employee participation in programs and provide employee incentives for training.
6. Communicate with other businesses and local governments.

FOR MORE INFORMATION

This summary highlights the findings of a research project described in an ABAG report, Hazardous Materials Problems During Earthquakes: A Guide to Their Cause and Mitigation. The research on which the Guide is based included an examination of records of hazardous materials problems collected by others, as well as ABAG staff interviews with a number of local governments and private businesses with first-hand experiences in the Coalinga, Livermore, Loma Prieta, and Whittier earthquakes in California. A companion document subtitled Background Materials contains checklists and guidelines, general articles by other researchers, samples of company and local government programs, liability and regulatory background information, and extensive lists of other references. In addition, a database of known hazardous material releases in 29 past earthquakes is available.

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Special thanks are given to Leslie Freeman and Lisa Martinez who worked with ABAG staff in documenting past earthquake problems and compiling the extensive earthquake reference list.

The production of this document was financed in part with a grant from the National Science Foundation. The report does not reflect the views of any federal agency, including NSF.

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